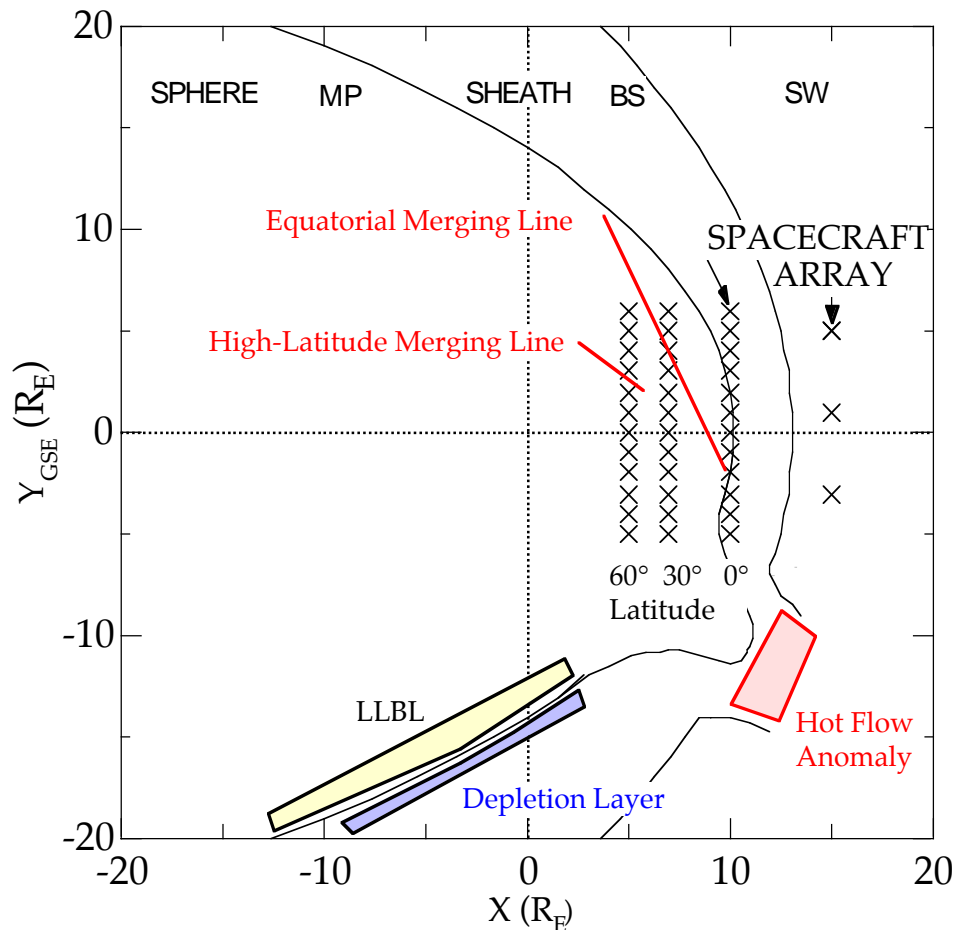


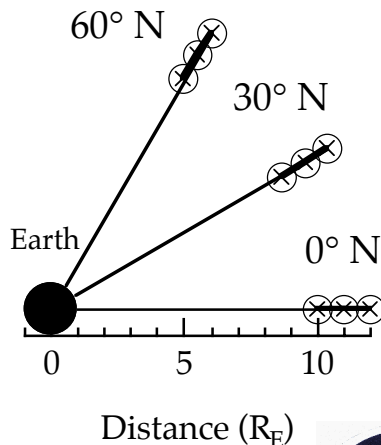
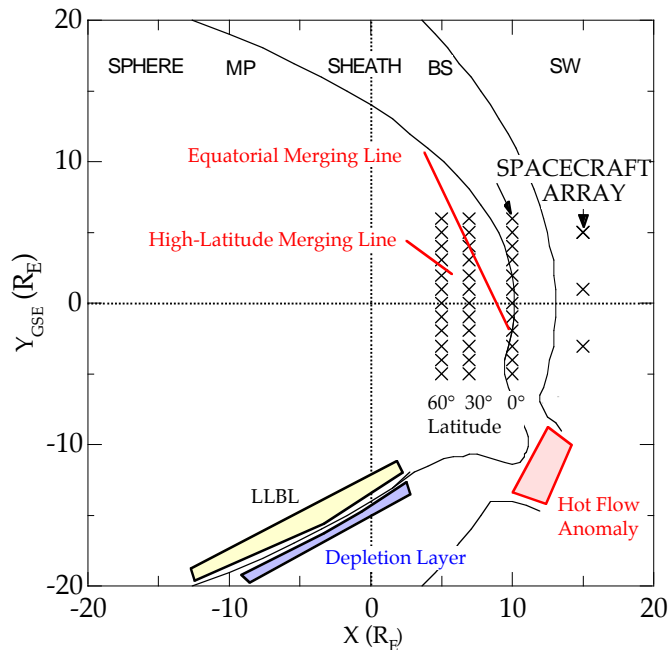
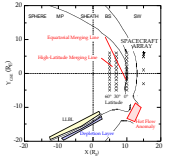
HERCULES: A Protecting Shield



(HERCULES schematic and quad charts prepared by D. Sibeck and B. Anderson)



Constellation HERCULES: Summary



Fundamental Question: “How do processes at the magnetopause and bow shock modulate the flow of solar wind mass, energy, and momentum into the magnetosphere?”

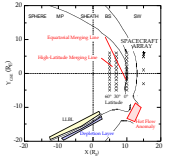
Science Objectives: Make visible the greatly distorted and ever moving bow shock and magnetopause structures which regulate the solar wind’s impact on the magnetosphere. Establish the causal relationship(s) between these boundary phenomena and corresponding solar wind, foreshock, and magnetosheath drivers.

Mission Description: A network of 36 small spacecraft, separated by $\sim 1 R_E$, skim both sides of the dayside magnetopause to provide simultaneous comprehensive observations of boundary phenomena over a wide range of latitudes and local times. 3 spacecraft hover near apogee outside the bow shock to monitor the foreshock-preconditioned solar wind input.

Measurement Strategy and Technology Requirements:

Vector magnetic field and plasma flow measurements from miniaturized plasma instruments on miniaturized spinning spacecraft injected into orbits covering a wide range of latitudes and longitudes. Synthesis into a continuous series of synoptic maps.

Constellation HERCULES: Further Explanation

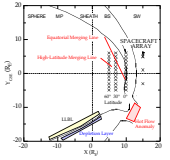


All of the solar wind mass, energy, and momentum that enter the magnetosphere must cross the Earth's bow shock and magnetopause. Over the past 30 years, in situ and remote observations have provided evidence for a wealth of steady-state and transient phenomena near both boundaries. Solar wind variations drive some phenomena, whereas intrinsic boundary instabilities generate others. Since the proposed interaction mechanisms regulate the flow of solar wind energy through the magnetospheric system, estimating the significance of each mechanism is an important step towards developing a quantitative model which can predict the occurrence of geomagnetic storms and substorms.

Of the various proposed and observed dayside interaction mechanisms, none is more important than magnetopause reconnection, which can account for the observed tendency of geomagnetic activity to increase during intervals of southward IMF orientation. Reconnection can assume many possible modes: steady or transient, localized or extended, equatorial or polar, directly-driven or due to sporadic instabilities.

To distinguish between these modes, one must determine when and where reconnection occurs. Past missions, and those currently planned, can address questions like these by employing individual spacecraft, or closely spaced pairs and clusters to identify the local signatures of reconnection. However, it is the dimensions of the reconnection regions which define their significance to the solar wind-magnetosphere interaction: the larger the portal through which solar wind energy can flow into the magnetosphere, the greater the significance of each reconnection mode. Because observations of reconnection at one point provide no evidence concerning its occurrence at another, past and presently planned missions will be unable to address this key question. Moreover, the pattern of reconnection on the dayside magnetopause is forever changing in response to constant variations in the interplanetary magnetic field, which controls the geometry, extent, and mode of reconnection.

Constellation HERCULES: Further Explanation



Researchers encounter similar problems when addressing the occurrence patterns of boundary layers produced by diffusion, flux transfer events produced by bursty reconnection, or boundary waves produced by the KH instability. Single point measurements cannot be used to determine the instantaneous extent.

The spatial extent and occurrence patterns of phenomena which occur in the vicinity of the Earth's bow shock are poorly determined. Recent work suggests that wave-particle interactions within the foreshock can greatly modify the solar wind plasma just before it interacts with the magnetosphere. Beyond the fact that these modifications must occur on dimensions comparable to, or less than, those of the magnetosphere itself, little is understood regarding the nature of foreshock preconditioning. Thus its full significance to the solar wind-magnetosphere interaction remains to be determined.

The Dayside Boundary Constellation mission will provide observations which can be used to image the variable geometry of magnetic reconnection and to record the changing, 3D configuration of processes in the foreshock and magnetosheath. Constellation spacecraft will be equipped with identical magnetometers and simplified plasma instruments capable of measuring solar wind, magnetosheath, and boundary layer plasmas. Several spacecraft will reach apogee immediately upstream from the Earth's bow shock to provide observations of the foreshock-preconditioned solar wind just prior to its interaction with the Earth's magnetosphere. The remaining 36 spacecraft will reach apogee in the vicinity of the magnetopause to provide *in situ* observations covering a wide range of latitudes and longitudes. Dayside observations will be used to monitor the extent and motion of the various steady state and transient features that occur on the dayside magnetopause. Nightside observations will be used to relate features in the ionosphere to those in the magnetotail and to improve models of the magnetospheric magnetic field.